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NOTES ON THE DETERMINATION OF ROCKY MOUNTAIN CONIFERS

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While working in a course in plant histology under the direction of Professor Aven Nelson two years ago, I found that the different species of the family Pinaceae occurring in the Central Rocky Mountain region could readily be separated merely on the internal structure of their leaves. Further study has led to the development of this paper.

In several instances, already, the key has proved of value in determining incomplete specimens in the Rocky Mountain Herbarium. Most of the species may be determined from a cross-section of a leaf merely by a hand lens, especially after one has become familiar with the terms used in the key and their significance. Cross-sections of dried leaves may be easily cut after boiling the leaves in water for a few minutes, and then putting them into 50 per cent. alcohol. Extremely thin sections are not at all necessary or advisable; in fact I have for my own amusement made determinations in the field (where it was not even necessary) with only a pocket knife and a hand lens. Not much variation occurs in leaves from a given species, but to avoid any possible confusion several leaves should be used. Particularly should sections be cut from four or five places along a leaf, so that typical sections may be secured. Since in some leaves not all the ducts will extend the full length of the leaf, this precaution becomes necessary. Fresh sections are sufficient for determination, but sections stained and cleared are much better. Fuchsin has been found to be a useful stain, since only the gross structure is necessary.

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This means of determination serves also to show the close relations existing between doubtful species. These will be discussed more fully under the species involved. So far I have dealt only with the subfamily Abietineae, excluding in our range the genus *Juniperus*. Good sections of the latter are so hard to obtain that it is very doubtful if a practicable key for this genus can be constructed on the basis of leaf-structure. The keys and descriptions of the species of the Central Rocky Mountain region (as given in Coulter and Nelson's Manual) follow, with diagrams where necessary. For the nomenclature I have followed Sudworth, in his 1897 report on the "Arborescent Flora of the United States."

Family PINACEAE.

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|---|------------------|
| Leaves needle-like; fruit dry cones. | 1. Abietineae. |
| Leaves scale-like or subulate; fruit (in ours) berries. | 2. Cupressineae. |

Subfamily ABIETINEAE.

- | | |
|--|-----------------|
| Walls of the mesophyl intruded, giving the cells a lobed appearance. | 1. PINUS. |
| Walls of the mesophyl not intruded. | |
| Stomata present on one side only. | 4. PSEUDOTSUGA. |
| Stomata present on all sides. | |
| Leaf strongly 4-angled; bundle-sheath conspicuous. | 2. PICEA. |
| Leaf strongly 4-angled; bundle sheath inconspicuous. | 3. ABIES. |

I. PINUS.

- | | |
|--|-----------------------------------|
| Cross-section triangular or wedge-shaped. | |
| Xylem of bundle not at all divided. | |
| Stomata present on all sides. | |
| All the resin ducts <i>usually</i> next to dorsal side (see descriptions). | 1. <i>P. flexilis</i> . |
| One resin duct <i>usually</i> found in the angle between the ventral sides (see descr.). | 2. <i>P. albicaulis</i> . |
| Stomata lacking on dorsal side. | 3. <i>P. aristata</i> . |
| Xylem of bundle divided. | 6. <i>P. ponderosa</i> . |
| Cross-section semicircular or crescentic. | |
| Xylem of bundle divided; ducts parenchymatous. | |
| Widely divided. | 5. <i>P. Murrayana</i> . |
| Very slightly divided. | 6. <i>P. ponderosa</i> . |
| Xylem of bundle undivided; ducts peripheral. | |
| Stomata <i>usually</i> more than 12. | 4. <i>P. monophylla</i> . |
| Stomata <i>usually</i> less than 12. | 4a. <i>P. monophylla edulis</i> . |
| Cross-section circular. | 4. <i>P. monophylla</i> . |

✓ 1. PINUS FLEXILIS James, Long's Exp. 2: 34. 1823.

Tree 12-25 m. high, trunk 5-10 dm. in diameter, bark grayish; leaves in fascicles of 5, 4-7 cm. long; cones narrowly ovoid to subcylindrical, greenish or light brown, 8-15 cm. long; the scales unarmed, broad, slightly thickened at ends, opening at maturity. Limber Pine.

Rather common on ridges and slopes; 7,000-10,000 ft. (See note under *P. albicaulis*.)

✓ 2. PINUS ALBICAULIS Engelmann, Trans. Acad. Sci. St. Louis 2: 209. 1868.

Very similar to the preceding; cones oval or subglobose, sessile, dark purple, 5-10 cm. long; the scales with thickened ends, remaining closed at maturity. White-bark Pine. (See also No. 1, *P. flexilis*.)

This and the preceding species are very closely related; in fact, Engelmann in Watson's Botany of California, II, makes *P. albicaulis* a variety of *P. flexilis*. In the cross-sections (see figures), *P. flexilis* usually lacks the resin duct in the angle between the ventral sides, although some of the specimens of this species appear to have it constantly. The two species can best be distinguished by their cones, the most noticeable and constant difference. Specimens without cones are readily confused.

✓ 3. PINUS ARISTATA Engelmann, Am. Journ. Sci. II. 34: 331. 1862.

12-15 m. high, 4-7 dm. in diameter; leaves in fascicles of 5, submucronate, green, with a white glaucous stripe on each side; cones violet-brown, narrowly ovoid, 7-10 cm. long; scales with thickened rhombic ends, with small beak and tipped with a lanceolate-subulate often recurved awn. Bristle-cone Pine.

Subalpine; from Colorado south, and west to California.

This can be readily distinguished from the others of this group by the lack of stomata on the outer side, and the deeply sunken stomata on the ventral sides. Sometimes only one resin duct is present.

PINUS.



P. ALBICAULIS. *P. FLEXILIS.* *P. ARISTATA.*



P. MONOPHYLLA. *P. MURRAYANA.* *P. PONDEROSA.*



ABIES *ABIES* *PSEUDOTSUGA*
CONCOLOR. *LASIOCARPA.* *TAXIFOLIA.*



FIG. 1. Cross-sections of the leaves of some Rocky Mountain conifers.

4. PINUS MONOPHYLLA Torr. and Frem., Fremont's 2d Rep. 319,
t. 4. 1845.

5-12 m. high, branched from or near the base; leaves single, in pairs, or (very rarely) in threes, 2-5 cm. long; cones sessile, subglobose, 4-6 cm. long; tips of scales thick, truncate, awnless; seeds large, brown, wingless, edible. Pinon or Nut Pine.

Texas, Colorado, Utah to Arizona.

The form in which all the fascicles contain 2-3 leaves should be referred to the variety *P. monophylla edulis*.

- 4a. PINUS MONOPHYLLA EDULIS (Engelm.) Jones, Zoe II. 1891.

Mr. Jones seems to have made proper disposition of this species in a report on the Flora of Utah, published in Zoe, 1891, reducing it to a variety of *P. monophylla*. Specimens of *P. monophylla* have been found in which there are actually more bundles with two leaves than with one, and these intermediate forms are frequent. *P. edulis*, therefore, seems to be a variety of *P. monophylla* in which all of the fascicles have two leaves (in very rare cases, three). So far as the sections of *P. edulis* and the two-leaved form of true *P. monophylla* are concerned, there is practically no difference. The variety *edulis* appears to have fewer rows of stomata than the species, but this character is not invariable. The sclerenchyma in the latter is often thicker than in the former, but not always.

The descriptions of the two trees, as given in Britton's "Trees of North America," coincide exactly, except for two points: in the description of *P. edulis* we find "leaves in sheathless fascicles of 2 or 3, triangular or nearly round, dark green, stout, 1.8 to 4 cm. long, entire," etc.; in the description of *P. monophylla* we find "leaves are solitary and round, rarely two or three in a sheathless fascicle, triangular, pale green and glaucous, round and stout, about 4 cm. long," etc. Now in the herbarium material that I have examined, numerous specimens of *P. edulis* may be found in which the leaves are "pale green and glaucous," in some cases as pale as, or even paler, than some of our specimens of *P. monophylla*. This difference, therefore, does not seem to be fixed. I have already spoken of the intermediate leaf forms; because of which Mr. Jones reduced *P. edulis* to

varietal rank. As these two unstable differences are the only definite ones given in the descriptions, there is no reason for keeping the later published one as a species distinct from the older. It is perhaps best to call the form in which all the leaves are in bundles of 2 or 3 a variety, *P. monophylla edulis* Jones, and to call the forms with single leaves the true species.

- ✓ 5. PINUS MURRAYANA Oreg. Com., in Murray Rep. Bot. Exp. Oreg. No. 740, t. 3. 1853.

Tall (15–30 m.) and slender; leaves semiterete, about 5 cm. long, in fascicles of two; cones small, adhering to the branches; scales armed with slender, sometimes recurved, prickles; seeds winged. Lodge Pole Pine.

Throughout the Rockies.

This species can readily be distinguished from *P. ponderosa* by the widely divided xylem, the xylem in *P. ponderosa* being but slightly divided.

- ✓ 6. PINUS PONDEROSA Douglas, in Lawson, Man. 355 (1836); Comp. Bot. Mag. 2: 111. 1836.

Usually a large tree, 25–40 m. high, 1–2 m. in diameter; leaves in fascicles of 2 or 3 (usually 3), 1–2 dm. long, crowded brush-like on ends of branchlets; cones 7–12 cm. long; scales thickened at the outer end, bearing a recurved prickle; seeds brown, winged. Rocky Mountain Yellow Pine.

Throughout the Rocky Mountains.

Distinguished from other species of this range by the xylem, which is slightly divided. This includes the so-called *Pinus scopulorum* (Engelm.) Lemmon, a species which is not essentially different.

II. PICEA.

Xylem of bundle not at all divided; 6–10 large heavy-walled strengthening cells at one side of bundle, in addition to the ordinary tissue.

1. *P. Engelmannii*.

Xylem of bundle slightly divided by one or two rows of larger, thinner-walled cells; no additional strengthening tissue present.

2. *P. pungens*.

1. *PICEA ENGELMANNII* (Parry) Engelm., Trans. Acad. Sci.
St. Louis, 2: 212. 1863.

25-40 m. high, much dwarfed and shrub-like at high elevations; branchlets puberulent; bark light-reddish; leaves 2-3 cm. long, abruptly acute; cones oval or oblong, brown, about 5 cm. long. Engelmann Spruce.

Throughout the Rocky Mountain region from middle to high elevations.

In the fibro-vascular bundle of the leaves of this species, large, heavy-walled, sclerenchymatic cells are found, usually 6-10 in a cluster on the opposite side of the bundle from the woody tissue. This and the following species are difficult to distinguish from each other, except in the field, and in the case of specimens with fully developed cones. The above key has proved satisfactory, if some degree of care be taken in cutting and staining the sections.

2. *PICEA PUNGENS* Engelm., London Gard. Chron. 1879: 334.
1879.

Lower than the preceding, conical in growth; bark thick, smooth and gray; branchlets smooth and shining; leaves 2-3 cm. long, extremely sharp pointed; cones cylindrical, 6-10 cm. long, light brown. Blue Spruce.

Colorado, Wyoming, and Utah.

No additional strengthening cells are found in the bundles of the leaves of this species. The xylem of the bundle appears to be divided very slightly, almost imperceptibly, except under the higher powers of the microscope.

In both these species, it is often difficult to get sections showing resin ducts. Sections may be obtained showing two ducts in opposite corners, but most sections will lack this number. It is hoped that this means of distinguishing between the two species will be of value in herbaria, where our two species are so often confused.

III. ABIES.

Resin ducts in middle of parenchyma.

1. *A. lasiocarpa*.

Resin ducts next to lower epidermis.

2. *A. concolor*.

1. *ABIES LASIOCARPA* (Hook.) Nutt., Sylva 3: 138. 1849.

20-30 m. high, with pale, thin, smooth, light-gray bark; leaves dark green, pointed; cones oblong-cylindrical, 6-7 cm. long, 3-4 cm. in diameter, purplish-brown; scales nearly orbicular or quadrangular, 12-20 mm. long and broad; seeds about 6 mm. long, with dark lustrous wings. Alpine Fir; Balsam.

Colorado and Wyoming to the Northwest.

In this species, the resin ducts are in the chlorophyl-bearing tissue, midway between the upper and lower epidermis.

2. *ABIES CONCOLOR* (Gord.) Parry, Am. Nat. 9: 204. 1875.

25-50 m. high, with a diameter of 6-12 dm., and rough grayish bark; leaves mostly obtuse, pale green; cones oblong-cylindrical, 7-12 cm. long, 3-4 cm. in diameter, pale green or sometimes purplish; scales 25-30 mm. wide, about half as high; seeds 8-12 mm. long, brown, with rose-colored wings. White Fir.

Colorado to California and thence northward.

In this species, the two resin ducts are next to the lower epidermis.

Both these species have the xylem divided, distinguishing them (in addition to the position of the stomata) from the following genus, which has the xylem undivided.

IV. PSEUDOTSUGA.

One species.

1. *P. taxifolia*.

1. *PSEUDOTSUGA TAXIFOLIA* (Lam.) Britton, Trans. N. Y. Acad. Sci. 8: 74. 1889.

35-75 m. high, 1-4 m. in diameter, with thick, deeply fissured, brown bark; leaves flat, 15-25 mm. long; cones 5-10 cm. long, subcylindrical; bracts exserted, 3-pointed, giving the cones a fringed appearance; seeds 6 mm. long, on upper side reddish-brown, on lower flat and white, winged. Douglas Spruce.

Throughout the Rocky Mountains to the coast.

This genus may be easily distinguished from the species of *Abies* in our range in two ways: the stomata are found only on the lower surface, and the xylem of the bundle is undivided, while in *Abies* stomata are present on both surfaces, and the xylem is divided.